

XIX. *Notices of some New Species of Strepsipterous Insects from Albania, with further Observations on the Habits, Transformations, and Sexual Economy of these Parasites.* By S. S. SAUNDERS, Esq.

[Read 6th December, 1852.]

HAVING met with several new Strepsipterous parasites, obtained from different species of *Hylæus* and *Odynerus*, and having had frequent opportunities of witnessing their metamorphoses at different periods, whereby many of the questions which had arisen as to the mode of effecting ingress and egress, the relative position of the dorsal and ventral surfaces on emerging, the expansion of the vaginal orifice in hexapod-bearing females, and other debateable points, (alluded to in my former communication published in the Transactions of the Entomological Society, vol. i. N.S. p. 43,) may receive further elucidation, I now proceed to lay before the Society the result of my observations, as classed under the following heads.

1. *Saltatorial Powers of the Hexapod Larvæ.*

These hexapod larvæ, when their segments are distended, are of a semi-transparent piceous hue, with minute black eyes, the thoracic region being somewhat inflated, and the segments thence gradually tapering towards the anal extremity; each distinguished, where superposed, by a fine transverse line of deeper brown, the three anterior segments having the posterior margin more broadly banded, the anal apex inclining to castaneous, with the base of the setæ piceous.

Those of *Xenos Rossii* are enabled to leap to the distance of full half an inch, but by what means this movement was effected I could not determine. They did not appear to double themselves round for this purpose, as in the case of the cheese-maggot (*Tyrophaga casei*, Curt.); nor did I observe that the effect was produced, as may be conceived, by the action of the tail and caudal setæ, as practised by the *Podurellæ*, Latr. They also repeatedly leapt upon the brush wherewith I had been inciting them to the performance of this feat, after having removed it, as I thought, above their reach. I afterwards observed the same process repeated in the hexapod progeny of the Strepsipterous parasite obtained from a species of *Ancistrocerus*.

2. *Mode of Attack by the Hexapod Larvæ.*

Having captured about the middle of July a large female

Polistes, with three prolific female parasites protruding from the dorsal segments of the abdomen, I selected from a *Polistes* nest a variety of its inmates, in different stages of development; namely, first, a well-conditioned ovum, with the yolk concentrated, the head and eyes partially discernible, but the embryo exhibiting as yet no signs of activity;—secondly, one in a more advanced state, the larva within ready to burst the superincumbent pellicle, and making vigorous efforts to do so,—but on placing some of the hexapods upon these, they invariably effected their escape.

I next chose two larvæ of moderate dimensions, carefully extracted, whereunto the hexapods very readily attached themselves in a singular manner, affixing both head and tail like leeches.

I had already noticed a similar proceeding on the part of certain hexapod larvæ of *Hylecthrus*, which, in the absence of any larvæ of *Hylæus*, I had placed upon some other larvæ of diminutive size, obtained from a *Polistes* nest, to which the former readily attached themselves in the manner aforesaid; sometimes commencing with a wriggling motion, and shortly afterwards remaining perfectly still, assuming by degrees a gibbous distended form. Fearing at first, from their apparently inanimate condition, that they might have been injured in some manner, I supplied several in succession, with the like results; when, disturbing one of the earliest so placed, I found it still alive, the body being moved about from side to side without withdrawing the head. The following morning, finding the hexapods still motionless, I again disturbed one of them, when it commenced coiling about with the same activity as before, retaining the head immovable, and apparently endeavouring to effect a breach; or perhaps already imbibing nourishment, as practised by the larvæ of certain *Diptera*, in which the resemblance to the leech is also carried out.

The *Polistes* larvæ, together with the hexapods, perished within two or three days, without any further operations on the part of the latter; but the subsequent experiment with the *Xenos* hexapods proved more conclusive.

At 2 p.m., one of these hexapods had affixed itself upon the back of the first of the two *Polistes* larvæ aforesaid (which by way of distinction may be designated as A. and B.), and at 5 p.m., had completely buried itself beneath the skin, in a transverse position; while another, which had stationed itself upon the ctenulated lateral margin of the segments, remained at the same period *in statu quo*. By the morning, however, the latter had

shifted its quarters, and was observed nearly buried beneath the skin, at no great distance from its companion, and later in the day both were completely out of sight.

The other larva, B., which had two hexapods placed upon it at 3 p.m., one of which had taken up its position on the breast, was found at 5 p. m., having this half-buried beneath the skin, the remaining portion recumbent, and attached outside. The second hexapod had fixed itself upon a lobe of the head, near the mentum, from which I was unable to detach it; but it subsequently removed, and in the morning was nowhere to be found, while the first had entirely and deeply penetrated within.

Other hexapods, placed upon a soft yellow *Polistes* pupa, left this unmolested.

3. *First Moul.*

About a week later, viz., on the 24th, seeing little prospect of rearing the said *Polistes* larvæ, to which I had administered in the interval moistened sugar, diluted honey, fruit, &c., with no appearance of relish on their part, I determined to institute a search for the hexapods within, in order to ascertain what their condition might be. On carefully opening B, and removing a dark globular mass, which is always met with in those larvæ, I found the hexapod which had penetrated on the 17th and 18th, in a somewhat distended condition, perfectly motionless, the head deflexed, the anterior segments humped, and obviously preparing to undergo its first moult, as seen in the silkworm.

In about half an hour, I observed that the juices of the *Polistes* larva were rapidly inspissating, while the hexapod itself appeared to have undergone some alteration; and on further examination, I perceived that the latter was then in the act of discarding its hexapod skin, the anterior portion being now pellucid white, without any trace of legs, furnished with two minute but very distinctly marked black eyes, and having the lower region still enveloped in the fuscous folds of the hexapod.

During the day, I also opened the other *Polistes* larva, A, and soon found the two hexapods which had penetrated on the 18th,—one having its head turned towards the anal extremity, the other lying transversely; neither, however, having undergone any metamorphosis.

4. *Position in the Feeding State.*

It would seem, from the foregoing remarks, that the position of the Strepsipterous larvæ in the incipient stage exhibits no uniformity, and that the hexapods indiscriminately attack any part of their victims, although eventually restricted to the abdo-

minal region, preparatory to their ultimate exit. The relative direction of the head appears to vary up to a late period, even when the *Hylæus* or other victim has assumed the pupa state. Among the specimens presented will be found a *Hylæus* nymph, wherein, on removing the terminal segments to the fourth, exclusive, I perceived the anal extremity of a Strepsipterous larva projecting. On separating the fourth segment, the head of the parasite was found directed towards the thorax, in which position it is still retained within the disrupted segment. After this, the third segment was in like manner removed, when three more larvæ of smaller dimensions were observed; one of which was lying transversely, the other two with their heads directed towards the anal extremity, and apparently in the act of forcing a passage between the adipose tissue and outer tegument of the bee, which operation had been commenced higher up. The whole were, however, of much smaller size than might have been expected at this period of their growth; but whether in consequence of there being four to be sustained by one bee, or from some other cause, must be left to conjecture.

5. *Mode of effecting Exit.*

The nymphs of those *Hylæi* which are likely to produce the pale-coloured specimens (*H. versicolor*), which prove, as anticipated, to be only a variety of the *H. rubicola* consequent upon parasitic absorption, may usually be identified within one or two days of their final metamorphosis, by assuming a yellow tinge, and may be set apart as certain to produce male parasites. I have not unfrequently been enabled to detect the eye-shades of the latter before the *Hylæus* nymph has discarded its pellicle, working to and fro beneath the dorsal tegument; although more conspicuous when the bee first attains the imago form, the head of the parasite being then seen turning from side to side, and steadily pressing all the while upon the rostrum, as the axis about which it revolves, in the ratio of one-eighth of a circle, for the purpose of introducing this between the abdominal folds. Thus when one eye-shade advances the other recedes, both being sometimes carried deeper below, when the greater strain appears to operate upon the upheld rostrum. As soon as a lodgment is effected, this is gradually pushed forward by a continuation of the same process, until sufficiently advanced, the entire operation occupying from one hour in some cases, to two hours in others, and immediately following the ultimate transformation of the bee in its then moist state; after which the parasite remains perfectly motionless.

I have sometimes seen three parasites thus engaged simultaneously within the same *Hylæus*; and should the attempt not prove successful, the locality is changed for the segmental division next in succession; or, if foiled again here, the parasite sometimes remounts to the preceding one. These efforts have been continued for upwards of an hour after a newly developed imago *Hylæus*, within which the eye shades were discerned, had been immersed in spirits, until at length the parasite appeared to have attained the extreme verge of the segmental threshold ere its career was finally arrested.

The same absorbent influences upon the *Hylæus* not being produced in the case of female parasites, nor any indication of their presence being supplied, as might be expected, by a distension of the abdominal region, no opportunity has been afforded, as in the case of the males, of observing their proceedings at the period of exit.

6. Occasional Exit from ventral Surface.

Instances have occurred when male parasites have effected their exit between the *ventral* segments of the *Hylæi*. A similar occurrence in the *Xenos* has been alluded to by Jurine, who states that he found their "tumeurs placées ordinairement entre les 3^e, 4^e et 5^e segmens abdominaux, plus frequemment en dessus qu'en dessous."

This anomaly having been witnessed in the *Hylæi* in those cases only where several parasites had been nurtured by the same individual, may be ascribable to impediments derived from want of space, although in some instances three fully developed pupa-cases have been protruded between the dorsal folds, and the imago duly produced from each.

Whenever any of the parasites have presented themselves on the ventral surface of the abdomen of the bee, the pupa-cases have been reversed, their relative position as regards the body of the bee being the same as usual, the rostrum pointing towards the abdominal segments.

7. Subsequent Metamorphoses.

a. Of the Male.

The head of the male *Hylecthrus* at the moment of protrusion is white, the eye-shades of a castaneous hue, and the rostrum presenting a semilunar piceous margin, forming an indurated apex, with a curvilinear lateral prolongation at the base towards

the eyes. The eye-shades are found to present at the time of exit the usual fenestrated disc, consisting of a number of minute transparencies disposed in regular rows. In the course of a few hours the pupa-case assumes a light castaneous tinge, which continues gradually darkening as the occult nymph approaches maturity, until at length discarding its slender pellicle, and advancing from its previous retractile position closer to the operculum, the black head from within produces a darkening effect upon the whole. If previously to this moment a needle be passed transversely through the operculum, the nymph remains uninjured thereby, nor does the removal of the operculum leave the head prominently exposed. When the operculum has retained a castaneous tinge, and not separated readily on pressure, the parasite may be considered as still immature; or should the bee die before the parasite is well advanced towards its ultimate metamorphosis, the latter may be expected to perish, from the want of the accustomed moisture; nor indeed, if in a more forward state, does it appear able to accomplish its final moult under such circumstances, remaining therefore perfect in all its parts, but still enveloped in the pellicle of the nymph.

b. Of the Female.

When first porrected from the abdomen of the bee, the cephalothorax of the female *Hylecthrus* is nearly diaphanous, with a piceous marginal induration, corresponding anteriorly with the proboscis in the operculum of the male, the deflexion of which in both would appear to indicate a similarity in the position and proceedings of the larvæ prior to egress.

The convex shield on the upper surface exhibits anteriorly two glossy protuberances seated in an angular recess on each side of the disc, being at first of a brown colour, which afterwards disappears by the dispersion of the subjacent humours, leaving, however, the site more transparent. On the lateral margin, at the extreme corners of the occipital suture beneath the shield, are two piceous tubercles, occupying the place of the eyes; the discal shield extending at first in close proximity to the indurated piceous apex of the cephalothorax, where, shortly after protrusion, a separation is effected in the natural course of development, whence the upper region of the true head becomes partially exposed. The superior lip, broad and rounded at the sides, traversed at the base by a delicate sutural line, is furnished in the centre with a small quadrate emarginate plate, having on each side a kind of obtuse palpiiform process, terminating in a glossy

tubercle, corresponding in position with those seen on either side of the rostrum in the operculum of the male; and in approximation to these, curving round from the base, are two deflexed shining corneous appendages, which may be considered equivalent to the mandibular organs of the male; the inferior lip curling over beneath.

In the course of a few days the apical region of the squamous disc becomes so much vaulted and foreshortened, that by a comparison of two female parasites bred from the same bee, it would appear as if in one of these an anterior lobe had been thrown off as an operculum, on a line corresponding above with a well-defined sutural curve on the concave surface below, marking the extreme limit of the true larva head, having, however, the vaulted prothoracic segment still partially carried forward hood-like above.

On a front inspection of this semi-lunar arched aperture in prolific females, a delicate membranous pellicle may be discerned within, (sometimes attached to the thoracic hood, and at other times separated,) presenting a well defined arcuate anterior margin, porrected beneath the convex shield, and corresponding with the prothoracic arch, whence it may be inferred that this disjunction is produced in like manner by a natural separation of parts; the base of the orifice being connected by piceous lateral nervures, swerving upwards from the lower region of the œsophagus towards the larva mouth in front.

On removing the superincumbent convex shield, the quadri-lateral thoracic duct, already perceptible through the disc, is found covered throughout with this flatly distended pellicle, which, for reasons afterwards explained, must be considered to extend over the whole of the thoracic region. This duct, henceforth serving as the vaginal channel, continues gradually widening until it reaches the soft abdominal segments; and eventually is used by the hexapod progeny as a kind of vestibule or marsupium for egress and ingress, according to circumstances, as noticed by Dr. Siebold, and witnessed also by myself. It has never occurred to me to find ova or immature larvæ therein, as in the instance alluded to by Mr. Newport;* in which case, however, the abdomen of the parasite having been previously "ruptured," the ova may possibly have been displaced.

At the origin of the mesothorax, where the disc of the shield is much inflated, a minute stigma may be traced on the lateral

* Linn. Trans. vol. xx. p. 337.

margin; the metathorax exhibiting a more conspicuous protuberance towards the basal angles of the thoracic shield, preceded by a well-defined stigma, visible on the marginal rim at the origin of this segment, and communicating with a deflexed nervure or tubular process, carried obliquely to the base of the thoracic channel on each side. These meso- and metathoracic stigmata may be considered to offer an analogy to the sockets of the pseudelytra and wings in the male.

Looking also to the original condition of the hexapod larvæ, and to their subsequent metamorphoses, it may be assumed that up to the moment of their protrusion from the abdominal segments of their victims in the pseudo-pupa state, both males and females have undergone similar and corresponding changes; whence it follows that the ultimate larva-skin or pupa-case, discarded by the male, and the exuviæ of the nymph, must co-exist in the female, which does not divest herself of either.

In fact, after having removed the upper region of the cephalothorax as aforesaid, on making a horizontal section of the subjacent parts, the existence of a separate inferior region of the cephalothorax, forming with the upper a complete exterior sheath, may be readily perceived, leaving the internal cephalothoracic organization distinct, with the vaginal duct entire; the pellicle covering which, and next in succession, (corresponding anteriorly in extent and arch with the apical margin of the prothoracic hood,) being equivalent pro tanto to the exuvial skin of the nymph; the true imago remaining intermediate, and exhibiting on the transverse sutural line at the base of the head, occupying a retractile position beneath the said porrected pellicle, two minute rufescent discal tubercles on the upper surface, which may possibly indicate the rudimentary condition of the antennæ. Thus an incomplete metamorphosis, analogous to that of the male, may be traced in the female, the desiccated outer tegument of the cephalothorax being only the incipient pupa-case of the real pupa and imago conformation within.

8. *Relative Position of the Dorsal and Ventral Surfaces.*

Whenever opportunities have presented themselves of ascertaining the position of the males prior to exit, I have found that the *Xenos* and its allies (namely, those parasites obtained from *Polistes*, *Oplopus*, Wesm., and *Ancistrocerus*, Wesm.) emerged from the pupa-case, as recorded by Dr. Siebold, with the ventral region uppermost; whereas the *Hylecthri*, as well perhaps as *Stylops* and others parasitic upon the softer bodied *Mellifera*,

usually present themselves in a converse position, with the *dorsal* region upwards; the back of the parasite in the former case being turned towards the back of the wasp, and in the latter case the ventral surface of the parasite resting on the back of the bee.

On the other hand, from the corresponding indications in the opercula of *Xenos* and *Hylecthrus*, and from a comparison of the projecting hood of the prothorax in the pupa-cases of the former with the analogous vaulted orifice in the females, &c., it is scarcely questionable that the relative position of the whole of these parasites on emerging from the abdominal folds is uniform in all cases, unless when protruded from the ventral segments of their victim.

Upon examining the orifice of the pupa-case of *Xenos Rossii*, presented to the Society (No. 2), from which the operculum has been separated, a sharp angular prolongation bent upwards is visible on the inferior margin, as if the abdominal segments of the wasp, between which the parasite had penetrated, had exercised too stringent a pressure upon the under side of the prothorax, thereby interfering with the aperture, which is rather oblong than circular, and bipartite in consequence of the bent up prolongation mentioned above, which must considerably impede the egress of the imago, as experienced by myself on one occasion when endeavouring to extract from the pupa-case the male of *Xenos Heydenii* after death.

No such obstacle is encountered in the pupa-cases of *Hylecthrus*, where the orifice retains the original circular form of the full fed larva, and the nymphs are found with the ventral region downwards, although I once observed in a reversed position a male of *H. rubi*, which had perished when in the act of divesting itself from the pellicle of the nymph.

The following inferences would appear to be deducible from the above recited facts: namely,

1. That the *pupa-cases* of the males in *Xenos* and *Hylecthrus*, &c. *correspond* in position.
2. That the position of the perfect *males* on emerging usually differs in *Xenos* and *Hylecthrus*.
3. That one or other must therefore turn within the pupa-case, a faculty which both appear to possess as nymphs.
4. That the *females* of all Strepsipterous parasites obviously coincide in position.
5. That in the *pseudo-pupa* state the *males* and *females* protrude between the abdominal segments of their victims in a similar position.
6. That it would therefore seem scarcely doubtful that the

convex upper surface in the females corresponds with the dorsal, and the concave under surface with the ventral region.

9. *Exit of the Imago Male.*

After the first burst, produced apparently by the parasite pressing forcibly against the operculum, the head and shoulders being instantaneously protruded on this falling off, a slight effort suffices to liberate the pseudelytra and first pair of legs; when all these organs idly beating the air and agitating incessantly, much exertion is made to effect a passage for the second pair of legs, where the principal detention occurs; after which a few jerks up and down speedily serve to release the metathorax and abdomen; the imago forthwith winging its flight towards the light, where it continues flitting up and down until its fragile frame becomes exhausted, and it sinks powerless below, still vibrating its wings but unable to rise again.

I have never succeeded in retaining them alive beyond the day of exit, and indeed they have not often survived more than a few hours, generally between two and three. Jurine, who was equally unsuccessful in this respect, suggested that their premature death might be occasioned by the continual blows received when coming into contact with the glass; but the same effects have been produced when I have allowed them to emerge within a pill box covered with fine muslin at top and bottom, and freely exposed to a current of air, with moistened cotton placed in front. Yet during their brief term of existence they are not so weak and helpless as may be supposed, for on one occasion when three male *Hylecthri* were obtained alive from a dead *Hylæus*, the first which exhibited itself commenced dragging the bee about behind him, together with his unemancipated comrades, until he succeeded eventually in effecting his escape from the pupa-case.

Sometimes the parasite has been observed to twist round upon the dorsal segments of the bee while making its exit, and then resume its original position, the whole operation occupying usually but a few minutes, and occasionally less than one. The ordinary period for quitting the pupa-case, in the *Hylecthri*, would appear to be about the eighth day after their first protrusion; nor upon careful investigation have I found any complete their final metamorphosis sooner than this, although sometimes protracted a day or two later. The darkening of the operculum serves to indicate the immediate presence of the imago in contiguity to the fenestrated lattices, watching for a fitting opportunity to effect its exit; when exposure to a full light, without sun, is sufficient to induce

it to make the necessary efforts for this purpose; nor are the parasites dependent on such occasions upon any assistance from their foster parents, I having on several occasions found them accomplish their deliverance by their own unaided exertions after the death of the latter, by placing the still moist bee in a glass tube on the window frame, having the operculum of the parasite directed towards the light.

To whatever cause the early death of the male parasites may be attributed, it is certainly retarded by detention within the pupa-case. I once found one alive five days after the death of the bee, and the thirteenth from the first appearance of the pupa between the abdominal folds: and in the case of Mr. Pickering's stylopized *Andrena*, found on Christmas Day, the parasite would probably have retained its pupa domicile for a much longer period.

10. Uniformity of Sex in collaterally developed Parasites.

I now proceed to offer some remarks upon the sexual economy of these parasites, and in the first place to notice the marked tendency which exists in those nurtured by the same Hymenopterous insect, to exhibit, when more than one is produced, a uniformity of sex.

These coincidences have been witnessed on so many occasions that they can hardly be ascribed to accident alone; twenty males and fourteen females of *Hylecthrus* having been obtained in corresponding pairs; twelve males and three females occurring by threes, and similar effects being also noticed in the parasites obtained from *Polistes*, *Oplopus*, and *Ancistrocerus*; nor have I ever found both male and female parasites associated in the same individual.

On the other hand, it is certain that both sexes of *Stylops Spencii* were met with by Mr. Pickering in one *Andrena*, as the figures given thereof clearly indicate;* so that in attempting to account for this agreement in sex as the usual, though not invariable, concomitant of such association among Strepsipterous parasites, subjected to the like conditions and influences during the whole period of their larva-growth, the result would seem to be attributable rather to the operation of some causes antecedent to the primary attack, than to influences derived subsequent thereto; and hence, following up the inquiry to the hexapods, and the ova from which they emanate, we are led to consider from what start-

* Trans. Ent. Soc. Lond. Vol. I., p. 172, and Pl. XVII.

ing point that divergence originates which eventually conduces to so marked a contrast between the highly developed external organization of the male, and the retroactive internal concentration of the vital energies in the female; or, as Dr. Hermann Burmeister has described these opposite tendencies, the active and passive agency displaying itself by "preponderance of evolution" in the one case, and "predominance of involution" in the other.*

Some analogous instances of homogeneous development are met with among those Hymenopterous insects which construct their larva abodes in a consecutive series, the sexes being retained distinct and separate, the cells of the one terminating before those of the other commence. So also among the *Vespidæ*, and in *Polistes* especially, a complete series of cells is at one time exclusively devoted to males, and another of larger dimensions set apart for females only, the ova producing which are consequently deposited in a continuous series: and the development of the fecundating principle being promoted by a difference in the quantity and quality of the food supplied.

It would seem, then, not unreasonable to attribute to Strepsipterous insects the tendency to disseminate their ovoviparous progeny in a sexual series, those attaining maturity about the same time, and emanating from the same ovarial division, being endowed as such with the constituent characteristics of one particular sex; although instances may occur in which both sexes have been nurtured by the same bee under precisely identical conditions and influences.

11. *Effects produced by the Parasites upon the reproductive Powers of their Victims.*

In attempting to account for the aforesaid associations, a preliminary difficulty presents itself in the supposed sterility of the insects attacked, whose vital functions are obviously affected thereby to a considerable extent, as many well-attested facts serve to establish.

That such a result should ensue in cases like that of the *Andrena tibialis*, from which three specimens of the *Stylops Spencii* were obtained, is scarcely problematical; and may also occur whenever the highly-developed organization of male parasites has been acquired at the expense of their victims, the effects produced being frequently exhibited in the absorbent influences upon

* Burmeister's Manual, translated by Shuckard, sects. 133 and 206.

the abdominal region, which is crippled and distorted also to a considerable extent by the desiccated conical pupa-cases of the male parasite, but apparently scarcely incommoded by the pressure of the female.

Mr. Newport indeed on one occasion, when only a single specimen of a female *Stylops* had been nurtured, found the oviducts of the bee "of ordinary length and size, but the ovaries entirely undeveloped, and scarcely larger than they are at the period when the bee-larva passes to the state of nymph. They contained only the germs of a few very imperfect ova."*

On the other hand, when speaking of the manner in which the hexapod larvæ of *Stylops* are transferred to the cells of their victims, he observes, "they cling fast to the hairs on the body of the wasp or bee in which they have been hatched, and are transported by the insect to its nest."† And again, "the *Stylops* hatched within its parent in the abdomen of the bee, issues forth and clings to the hairs which cover the body of the fated insect, and thus at once has a means of conveyance on the bee to her nest, in which it is to be fed."‡

These remarks, which necessarily assume the victim to be capable of constructing brood-cells, and of depositing eggs therein, are in perfect unison with Dr. Siebold's views upon this subject, as expounded under his seventh result, wherein he states, "Die sechsbeinigen Strepsipteren-Larven kriechen auf dem Abdomen der *Hymenopteren*, in welchen ihre mütter wohnen, munter umher. Diese Strepsipteren-Larven lassen sich auf diese weise in die nester der *Hymenopteren* tragen, wo sie alsdann gelegenheit finden, sich durch die weichen Körper-Bedeckungen der Hymenopteren-Larven hindurch zu arbeiten, und in die Leibeshohle derselben zu gelangen."§

If, indeed, in accordance with the opinion first suggested by Kirby, and generally assented to by others, as to the probable effects upon the reproductive powers in the case of the male parasites, the same results be also attributable to the females, and their hexapod progeny consequently be always dependent upon fortuitous means of access to the larva-cells of prolific individuals; the circumstance of the subsequent co-ordination of the sexes in these parasites, indiscriminately dispersed in the first instance and assembled at random afterwards, could only be ascribed to some

* Loc. cit. p. 335.

† Loc. cit. p. 334.

‡ Loc. cit. p. 350.

§ Weigmann's Archiv für Naturgeschichte, 1843, p. 139.

influence operating during the period of larva-growth, which we should scarcely be warranted in assuming.

How, moreover, should we account for the circumstance of the *Polistes*, the *Hylæi*, the *Andrenæ*, the *Odyneri* and others visiting simultaneously the same flowers and localities, being always attacked by their own peculiar species of parasites, and these retaining unimpaired their consistent associations in one unbroken line of descent?

If, again, it be averred that out of a number of hexapods promiscuously conveyed to the cells, those only which may prove to be of precisely suitable condition and habits obtain an available domicile, this would scarcely hold good among nearly-allied groups, nor can it be conceived that the hexapods themselves should be enabled to discriminate their appropriate abode, where no palpable difference may exist in the store, before even the larvæ upon which they are to subsist are extant in the cells; still less that these hexapods, produced in such myriads, should not, that I am aware of, like the yellow hexapods of *Meloe*, described by Mr. Newport, be frequently met with in profusion upon certain flowers, as well as upon various Dipterous and Hymenopterous insects.*

While, therefore, the sterility of the victims in certain cases may be deemed incontestable, the general enunciation of this principle would appear to be incompatible with the known conditions affecting the perpetuation of the species in the parasites, although a large proportion of these must necessarily perish in the hexapod larva state, without obtaining a suitable abode—excessive numbers serving to provide, as in many other well-known instances, a compensating medium in this respect.

Some hexapod larvæ of *Hylecthrus* having on one occasion been placed by me upon a very diminutive *Polistes* larva, I found them attach themselves without hesitation in the usual manner, remaining affixed thereto, without, however, succeeding in penetrating, nor did they afterwards abandon the position so taken up. If, however, the hexapod larvæ of all Strepsipterous insects be left, in the ordinary course of events, to chance conveyance by any bee or wasp to any cell to be reared, as occasions may offer, upon the larvæ of any victim answering to certain required conditions, the manner in which those conditions would often be found fulfilled among allied genera and species must lead to interminable confusion in the distribution of the parasites, instead

* Loc. cit. p. 310, et seq.

of each being retained, as at present, within its own allotted sphere.

12. *Inferences as to double-brooding in the Xenos.*

Having been induced, on a former occasion,* to hazard a conjecture as to the existence of double broods in *Xenos*, from certain deductions drawn in connexion with the known economy of *Polistes*, and the early appearance of the hexapod larvæ of the parasites, as noticed by Dr. Siebold (their identity,† however, with those of *Xenos* requiring confirmation), the following facts, which have since come under my observation, may be deemed to afford some corroborative testimony in this respect.

On the 4th of July, I captured at large a male *Polistes*, bearing a well-developed female *Xenos*, having the vaginal orifice fully expanded. This *Polistes* was necessarily reared from a larva of the same year, since none but females hibernate. The *Xenos* must consequently have been produced from a hexapod deposited in the larva cell of the *Polistes* about the same period. But this male *Polistes* was doomed to perish before the ensuing winter; therefore, any progeny to which its parasite might have given birth, if available for the continuation of the species, would require to be introduced forthwith to the larva cells of another *Polistes*, in conjunction with whose female brood the young hexapods might again be enabled to fulfil the required conditions of maturity and fecundation, and thus transfer their posterity, together with the hibernating *Polistes*, to the following year. Under any other circumstances, it must be assumed that all female parasites met with in the males of *Polistes* (which Rossi states to be more subject to such attacks than the females‡) can take no part in the continuation of the race.

Similar deductions may also be drawn in the case of the female *Polistes*, exhibiting three prolific females of *Xenos*, already adverted to when describing the proceedings of the hexapods so obtained. This was on the 17th of July; yet in the preceding instance of the male *Polistes*, it has been shown that an early brood or series of hexapods had already finished their transformations and attained the perfect state at least a fortnight earlier. On the other hand, it is manifest that these hexapods produced subsequently, must secure a larva-domicile and accomplish their metamorphoses before winter, in order that when the *Polistes* quit their hibernacula in the spring, the *Xenos* females may dis-

* Trans. Ent. Soc. Lond. Vol. I. (N. S.), p. 50.

† Loc. cit. p. 143; Results 29 and 30.

‡ Faun. Etrus. Mant., Append., p. 115, note.

pose of their hexapod progeny as required, and thus complete their destined cycle of existence.

13. *Impregnation of the Female.*

It only remains to notice some experiments made as to the pairing of the sexes in the *Hylecthri*, I having on various occasions, when male parasites were obtained, selected bees bearing specimens of their apterous partners for the purpose of introducing these into the glass tubes containing the former. More difficulty, however, being experienced in retaining the bees alive when nurturing female parasites than when encumbered with the conical pupa cases of males, these experiments were for some time limited to newly-protruded specimens of the former, which the males were in nowise disposed to notice; although, while the latter were incessantly quivering up and down towards the light, I was enabled to bring the females conspicuously before them by keeping the bees turned in that direction, so that the male parasites were continually traversing their path, or even crossing over them.

Conceiving at length that these female parasites had possibly not attained the required degree of development, I selected one which had emerged five days previously, placing the bee in the same bottle with two male parasites whose exit from the pupa-case had just been accomplished, when impregnation was several times attempted on the part of both males; but the *Hylæus* being in a feeble condition, and in fact dying later in the day, was frequently falling from side to side, having no power to retain a firm footing anywhere. The abdomen of the male was on each occasion strongly recurved in the direction of the squamous cephalothorax of the female, the same proceeding being noticed ten or a dozen times, the males flying off and returning at intervals. They, however, as usual, only maintained their activity for about the space of two hours, after which they remained exhausted and helpless, so as to be shaken out on paper without risk of escape.

About a fortnight later another opportunity presented itself of witnessing similar results. A bee exhibiting a female parasite, having completed its transformations on the 25th June, was placed the same day in a phial containing a newly-issued male *Hylecthrus*, without the slightest notice being taken of the former, although repeatedly brought in the way of the latter. The following day the experiment was renewed with other males, some of these inclosed in a muslin-covered box, but without effect. On the third day, having introduced the same *Hylæus* to a phial containing a male parasite which had just quitted the pupa-case, the latter immediately settled upon the abdomen of the bee, qui-

vering his expanded and uplifted wings, while recurving the abdomen considerably in the direction of his secluded partner, and returning on several occasions to repeat the same process, although the pairing may not have been fully consummated on any of these occasions, the *Hylæus* being, as in the former instance, in a disabled state, and dying in the course of the day.

DESCRIPTIONS OF NEW SPECIES.

1. *Xenos Heydenii*.

Long. corp. $\frac{1}{12}$ unc., mas.

The male is much smaller and more elongate than that of the *Xenos Rossii*, having also the antennæ less lanceolate. The female has the cephalothorax more acuminate and of a dark piceous hue, with a strongly-marked longitudinal impression near the lateral margin on each side of the prothoracic disc.

Inhabits the bodies of *Ancistrocerus deflendus*.

Of the male I only obtained a single specimen, extracted in a bad condition after death, the *Ancistrocerus* bearing the pupa of which, having been taken on the 5th July, died on the 8th, when on partially removing the operculum the nymph of the parasite was found still pale; but it changed from white to black on the 9th, and was extracted dead in the imago state on the 13th. The operculum also, on internal inspection, differs from that of *Xenos Rossii* in its markings and transparent portions.

Of the female I obtained several specimens, captured from the 29th June to the 10th August, and among these some producing hexapods on the 13th July and 9th August. The *Ancistroceri* were chiefly met with on the flowers of the wild peppermint in localities sheltered from the wind.

I have been induced to attach to this species the name of the Senator Van Heyden, who is recorded in our Transactions* to have met with a new *Xenos* in a small *Odynerus*, which, however, he conceived to have been the *O. auctus*.

Found in the neighbourhood of Prevesa and the Ambracian Gulf.

The *Ancistrocerus* from which this was obtained, apparently an undescribed species, has the clypeus black, with a well-defined broad yellow band across the base and embracing the angles on each side, a truncate frontal mark, a spot in front of each eye, and a streak behind their posterior margin, yellow. Antennæ black, the basal joint yellow beneath. Mandibles straight, somewhat rufescent, yellow at the base, with the inner dentate margin

* Trans. Ent. Soc. Vol. I. p. lxxiv.

black. *Thorax* anteriorly banded with yellow; the scapula of the wings and a spot beneath the same of variable size, the posterior angles more or less, and two transverse bands across the scutellum, the anterior one usually broadest, entire or bilobed, yellow. *Abdomen* having the posterior margin of each segment except the last in the female, and the two last in the male, broadly yellow, which in the first segment is dilated on each side towards the base; the second segment campanulate, with a large isolated basal pustule of the same colour on each side, sometimes entirely absent; all the segments having the yellow margins traversed by a close irregular double series of black punctures. *Legs* yellow, with the base of the femora black, and the apex of tarsi testaceous; body somewhat piceous beneath, the posterior margin of the second abdominal segment yellow. *Wings* hyaline.

The male differs in having the clypeus entirely yellow, or with only a small discal black marking, and the penultimate and anal abdominal segments bearing a yellow pustule.

Long. corp. 4 $4\frac{1}{2}$ lin.

Alar. exp. $5\frac{1}{2}$ 6 lin.

I propose to designate this species by the appellation of *A. deflendus*, in allusion to its parasitic infliction.

2. *Xenos Klugii*.

I have only seen males of this species, parasitic on the *Odynerus* (*Oplopus*, Wesm.) *rubicola* of Dufour, which were obtained after the death of the *Odynerus*, extracted from its earthen cells in briars. It is somewhat smaller than the *X. Rossii*, the body black, the legs and antennæ pale, the latter elongate and tapering, and the operculum materially differing from that of the pupa-case of the former, nor, considering the very different economy of the *Polistes* and the *Odynerus*, can this parasite coincide in habit with the *X. Rossii*, or transfer its progeny through the medium of hibernating females.

Found in the same localities as the preceding.

Hylecthrus Sieboldii.

This species is parasitic on the *Prosopis variegata*, Panz., several specimens of the latter, producing female parasites, having been captured during June, July, and the beginning of August, on the flowers of the wild peppermint, and one of these with a brood of hexapod larvæ on the 5th July. Another of the same bees, bearing the exuviae of a male parasite, was taken on the 16th July. The cephalothorax in the female of this species is distinguished by a broad yellow longitudinal band dilated towards the apex, and by a

dark transverse line at the base, interrupted by the passage to the abdominal region.

Found in sheltered places on the peninsula of Prevesa. This *Procospis* does not, however, nidificate in briars.

DIAGNOSIS OF SPECIMENS PRESENTED TO THE SOCIETY.

1. *Xenos Rossii* ♂ in the act of emerging from the pupa-case, having already cast off the pupa skin; the *ventral* region uppermost. (With *Polistes* ♀ captured July 15th.)

2. Pupa-case of another from the same species of *Polistes*, extracted entire, showing indented orifice; together with the operculum of the same; the cast off pellicle of the nymph at the extremity within.

3. *Xenos Rossii*, two females, protruding from the abdominal interstices of *Polistes*. (Captured July 5th.)

4. Hexapod larvæ of *Xenos Rossii*. (From another *Polistes*, July 18th.)

5. *Xenos Heydenii* ♀, with *Ancistrocerus deflendus* ♂.

6. *Hylecthrus rubi* ♂ in the act of emerging from the pupa-case; the *dorsal* region uppermost. (With *Hylæus rubicola*, var. *versicolor* ♂.)

7. *Hylæus versicolor* ♀ bearing two pupa-cases of *Hylecthrus rubi* ♂, with circular orifices.

8. Pupa-cases of *Hylecthrus rubi* ♂, with the opercula in situ, one of which protruded from *ventral* segments of the bee. The parasites apparently immature within. (With *Hylæus versicolor*.)

9. *Hylecthrus rubi* ♂ in imago state.

10. *Hylecthrus rubi* ♀ on first emerging; a bred specimen. (With *Hylæus rubicola* ♂.)

11. Another bred specimen of the same in a more advanced state.

12. Pseudo-pupa of *Hylecthrus rubi* ♂ previously to protrusion. (With nymph of *Hylæus versicolor*; the apical segments removed.)

13. Feeding larvæ of *Hylecthrus*, in different positions. (In section of abdomen of nymph of *Hylæus versicolor*.)

14. Nymph of *Hylecthrus rubi* ♂, with pellicle longitudinally separating preparatory to exit.

IN SPIRITS.

15. Nymph of *Hylæus versicolor*, the last three segments of abdomen removed, showing two male pseudo-pupæ of *Hylecthrus rubi*, not previously apparent.*

16. Pseudo-pupa of male parasite, as recognized by eye-shades, and proboscis working for egress within abdomen of the bee. (With newly-developed *Hylæus versicolor*.)

* From the rostrum of that to the right (the left in Pl. XVI. fig. 5) a portion of yellow fluid was ejected on handling the nymph of the bee, whence the buccal orifice may be considered in a normal condition at this period.

17. Immature white pupa of male parasite as just emerged from abdomen of the bee. (With newly-developed *Hylæus versicolor*.)

18. Pale nymph of *Hylecthrus quercus* ♂, extracted from the pupa-case. (Largest specimen.)

19. Pale nymph of *Hylecthrus rubi* ♂, the wings distended. (Smaller pale specimen.)

20. Nymph of *Hylecthrus rubi* ♂ in a more advanced state, with the limbs of the imago more distinctly shown. (The larger dark specimen.)

21. Extremity of body of *Hylæus rubicola*, with bred specimen of the female parasite (*H. rubi*), extracted entire after the protrusion of the cephalothorax.

" DESCRIPTION OF PLATES.—PLATE XV.

Fig. 1—8. Details of pseudo-nymph of *Xenos Rossii* ♂.

1. Head-case seen from above; 2, sideways; 3, from front; 4, from within; 5, body, with head-case removed; 6, front orifice, showing raised conical under edge; 7, one of the spiracles; 8, extremity of body wrinkled, inclosing pellicle of true pupa.
9. *Optopus rubicola*, Duf., with *Xenos Klugii*, S. S. S., ♂, inclosed in its pupa skin, with the head of another pseudo-nymph ♂; 10, antenna extracted from pupa skin of *X. Klugii* ♂ (basal joints not clearly seen); 11, head-case of pseudo-nymph ♂ from below; 12, from the front; 13, from within; 14, sideways; 15, portion of ventral surface near the head-case pointed (accidentally?).
15. *Ancistrocerus deflendus*, S. S. S., with *Xenos Heydenii*, S. S. S., ♀; 16, pseudo-nymph of *X. Heydenii* ♂ in pupa skin; 17, antenna extracted; 18, head-case of pseudo-nymph ♂ from below; 19, sideways; 20, from the front; 21, from within; 22, cephalothorax of ♀, 23, front of ditto magnified more strongly; 24, front margin seen in front.

PLATE XVI.

Fig. 1. *Xenos Rossii* ♂ escaping from dorsal articulation of abdomen of *Polistes gallica*.

2. *Hylecthrus rubi*, S. S. S., ♂, escaping from dorsal articulation of abdomen of *Hylæus rubicola*; 3, pupa of *Hyl. rubi* ♂; 4, ditto with pellicle longitudinally splitting preparatory to exit; 5, abdomen of pupa of *Hylæus*, with terminal segments removed, showing two pseudo-nymphs of *Hyl. rubi* ♂ not previously apparent (eye covers not coloured); 6, pupa of *Hylæus* with pseudo-nymph of ♂ parasite working for egress, the dark eye shades visible through tegument of bee-pupa; 7, head-case of immature white pupa of *H. rubi* ♂ just emerged from within the abdomen; 8, head-case sideways; 9, front of head-case more magnified; 10, extremity of body of *Hylæus*, with exuviae of two males of *Hyl. rubi* after removal of their head-cases showing oval aperture; 11, extremity of abdomen of *Hyl. rubicola*, with *Hyl. rubi* ♀; 12, front of cephalothorax ♀; 13, ditto seen laterally; 14, upper pellicle of cephalothorax of ♀ removed from fig. 15, which thus shows the thoracic duct covered with its membranous pellicle; 16, cephalothorax of *Hyl. rubi* ♀ (bred) with fuscous markings in place of eye shades; 17, ditto with outer dorsal pellicle of upper membrane of thoracic duct removed, showing articulations.
18. Pupa of *Hylecthrus quercus* ♂.
19. *Prosopis variegata*, with cephalothorax of *Hylecthrus Sieboldii* ♀ exposed; 20, the latter magnified greatly, showing two larvæ within the thoracic duct." [J. O. W.]